

2 METHOD OF PRODUCING CORROSION RESISTANT METAL
3 ALLOYS WITH IMPROVED STRENGTH AND DUCTILITY

4 The present invention relates generally to the formation of a metal alloy having desirable
5 properties in addition to ductility, despite the presence of a high content of chromium therein and
6 is a continuation-in-part of the disclosure in prior copending application Serial No. 09/233,907,
7 filed January 21, 1999, ^{now abandoned}
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9 BACKGROUND OF THE INVENTION

10 Nickel-chromium alloys with chromium contents of 40% by weight or more have
11 extremely low ductility. An improvement in both strength and ductility by casting of such high
12 chromium content alloys was totally unexpected.

13 The use of spray casting in the formation of metal alloys having a low chromium content
14 is generally well known. Such process involves the use of an atomizing gas to which the molten
15 alloy is exposed as disclosed for example in U.S. Patent Nos. 4,117,209, 4,606,948, 4,977,950,
16 5,017,250, 5,154,219, 5,489,417 and Re31,767, respectively issued to Markin et al., Hajmrle et
17 al., Muench, Ashok, Watson et al., (2), and Brooks. U.S. Patent No. 4,779,802 to Coombs is of
18 interest in regard to spray forming atomization. Only the foregoing referred to Markin et al. and
19 Hajmrle patents also relate to use of the spray casting process for nickel-chromium types of
20 alloys, expressly limited to low content chromium of 20% by weight or less. The production of
21 Nickel-chromium alloy is also disclosed in U.S. Patent No. 5,843,587 to Nakamori for use as a
22 gas turbine blade coating without regard to increasing alloy strength. The spray casting process
23 was not heretofore expected to produce a metallic nickel type of alloy having the advantage of
24 high ductility in connection with a high chromium content in excess of 40% by weight.
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1 It is therefore an important object of the present invention to provide a method for
2 producing a metallic alloy with a high chromium content, having an increase in both strength and
3 ductility despite the normally expected presence of brittleness associated with high chromium
4 content alloys.

5 SUMMARY OF THE INVENTION

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7 In accordance with the present invention, a spray metal forming process is utilized to
8 produce an alloy, wherein the alloy components are melted and mixed under cover of an inert gas
9 and allowed to form a molten metal outflow stream that is atomized into a fine spray of molten
10 droplets directed onto a moving or stationary surface. The alloy components are selected and
11 exclusively limited to nickel and chromium, respectively constituting between 48% and 52% by
12 weight of the alloy while nitrogen is selected as the inert cover gas. The referred to atomization
13 of the outflow stream of molten metal is effected by jets of the nitrogen gas pressurized for rapid
14 surface deposit of the molten droplets having a very fine and uniform grain structure. A ductile
15 matrix is thereby created in the deposited alloy with a fine dispersion of brittle phases in the
16 formation of chromium nitrides resulting from mixing of the alloy components under cover of
17 nitrogen as a crucial selection of the inert cover gas and exposure of the molten alloy outflow
18 stream to such nitrogen gas pressurized for atomization purposes. Improvement in ductility, as
19 well as a boost in strength of the ductile matrix was successfully achieved as a result of the
20 selection of nitrogen as compared to argon as the inert cover gas.

21 BRIEF DESCRIPTION OF DRAWING

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23 A more complete appreciation of the invention and many of its attendant advantages will
24 be readily appreciated as the same becomes better understood by reference to the following
25 detailed description when considered in connection with the accompanying drawing wherein:
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1 The drawing is a block diagram schematically illustrating the alloy forming process of the
2 present invention.

3 DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

4 Referring now to the drawing, the method or process of producing an alloy composed
5 exclusively of nickel and chromium in accordance with the present invention is diagrammed.
6 Such method involves alloy content selection 10, pursuant to the present invention, in association
7 with a spray metal casting or forming process 12 generally known in the art. As indicated in the
8 block diagram, alloy content selection 10 involves use of between 48% and 52% by weight as the
9 nickel content 14 and 52% to 48% by weight as the chromium content 16. Such alloy
10 components initially undergo heating 18, within a receptacle such as a crucible, under cover of
11 nitrogen selected as the inert cover gas in order to melt the nickel and chromium and allow an
12 outflow 20 of a stream of molten alloy metal from the bottom of the crucible, as part of the
13 diagrammed spray metal forming process 12. The nitrogen gas is also pressurized as denoted by
14 reference numeral 22 and introduced as jets into the molten metal outflow 20 so as to atomize the
15 outflow stream and break it up into a fine spray of molten metal droplets. Such molten droplets
16 or particles undergo deposit 24, by direction onto a rotating or stationary mandrel surface for
17 example, resulting in billets or shapes having a very fine and uniform grain structure.

18 The foregoing described method was utilized to deposit fifty (50) pounds of alloy of 50%
19 by weight of nickel and 50% by weight of chromium within a minute. The alloy so produced had
20 a yield strength of 145 ksi and tensile elongation of 25% or greater. The exposure to the nitrogen
21 gas during heating of the alloy content and its atomization by such nitrogen gas during the spray
22 metal forming process 12 created a high strength ductile alloy matrix with a substantially eutectic
23 and fine grain structure of 100 micrometers or less in average grain size as well as a uniform
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1 microstructure. Also because of the fine chromium nitrides formed by such exposure to the
2 atomizing nitrogen gas, a boost in alloy strength occurred.

3 The alloy fabrication method hereinbefore described may be beneficial in the formation of
4 any alloy that is normally brittle due to the presence of TCP phases, by virtue of the fine
5 dispersion of such phases within the ductile matrix.
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7 Obviously, other modifications and variations of the present invention may be possible in
8 light of the foregoing teachings. It is therefore to be understood that within the scope of the
9 appended claims the invention may be practiced otherwise than as specifically described.

10 What is claimed is:
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